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ON THE THEORY OF PREBIOTIC EVOLUTION¹

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ABSTRACT

The main theorems of the theory of evolution of open catalytic systems are briefly presented. The difference between the “natural-historical” and “actualistic” approach to the problem of the origins of life was highlighted.

Keywords: biogenesis, theory of evolution of open catalytic systems.

Dear Włodzimierz Ługowski!

I was pleased to learn that a Polish philosopher dealing with the problems of self-development of matter and the origin of life drew attention to my scientific and theoretical works on the self-development of open catalytic systems² and the general theory of chemical evolution and biogenesis,³ and

¹ The title and footnotes—from the translator (W. Ł.).

² А. П. Руденко [A. P. Rudenko], *Теория саморазвития открытых каталитических систем* [Theory of Self-Development of Open Catalytic Systems], Moscow 1969.

³ А. П. Руденко [A. P. Rudenko], *Эволюционный катализ и проблема происхождения жизни* [Evolutionary Catalysis and the Problem of the Origin of Life], in: Р. С. Карпинская [R. S. Karpinskaya] (ed.), *Взаимодействие методов естественных наук в познании жизни* [Interaction of Methods of Natural Sciences in the Knowledge of Life], Moscow 1976, 186-235; idem, *Эволюционная химия и естественно-исторический подход к проблеме происхождения жизни* [Evolutionary Chemistry and Natural History Approach to the Problem of the Origin of Life], Журнал Всесоюзного химического общества им. Д.И. Менделеева [Journal of the All-Union Chemical Society named after D.I. Mendeleev], 1980 (4), pp. 390-404; idem, *Физико-химические основания химической эволюции. I. Объекты химической эволюции*, [Physicochemical Foundations of Chemical Evolution. I. Objects of Chemical Evolutions, Журнал физической химии [Journal of Physical Chemistry], 1983, 57, 1597-1608; idem, *Физико-химические основания химической эволюции. II. Закономерности химической эволюции* [Physicochemical Foundations of Chemical Evolution. II. Patterns of Chemical Evolution], Журнал физической химии [Journal of Physical Chemistry], 1983, 57, pp. 2641-2658; idem, *Роль химии в решении проблем химической эволюции и биогенеза* [The Role of Chemistry in Solving Problems of Chemical Evolution and Biogenesis, in: Ю. А. Овчинников [Yu.A. Ovchinnikov (ed.), *Химия и мировоззрение* [Chemistry and Weltanschauung], Moscow 1986, pp. 266-292; idem, *Химическая эволюция и биогенез* [Chemical Evolution and Biogenesis], *Философия и социология науки и техники. Ежегодник* [Philosophy and Sociology of Science and Technology. Yearbook], Moscow 1987, pp. 70-87.

not only paid attention, but analysed the main points in the most detailed way my concept, and gave its philosophical interpretations, considering not only the concept itself, but also the responses, interpretations, positive and negative critical statements that exist in the literature. I was pleasantly surprised by the depth of your understanding of the essence of the concept under consideration and its individual theoretical provisions. In a number of cases, following the real logic of my provisions, you stood up for their defence and exposed one-sided or superficial understanding of them by other authors (in some articles by V. V. Orlov, T. S. Vasilyeva, O. A. Barg⁴) or biased, dishonest criticism (in the articles of L. Ya. Näpinen⁵). Your insight and accuracy in identifying the main thing in the analysed concept is all the more surprising because the understanding of my concept by other researchers is usually reduced to its individual moments, while inattention to others, sometimes more important. At the same time, I am once again convinced that a correct assessment of each new step in the development of our ideas about the world, about identifying new laws of nature is impossible without a deep understanding of the essence of scientific and theoretical achievements and their philosophical generalization.

Now I would like to dwell on one scientific and theoretical issue related to the problem of biogenesis, insufficient understanding of which led even you to the dubious conclusion that part of the interpretational misunder-

⁴ О. А. Барг [O. A. Barg], *Закономерный характер возникновения живой материи* [*The Law-Based Nature of the Emergence of Living Matter*, in: В. В. Орлов [V. V. Orlov] et al. (eds.), *Развитие материи как закономерный процесс* [*The Development of Matter as a Natural Process*], Perm 1978, pp. 78–85; idem, *О теории химической эволюции А. П. Руденко* [*About the Theory of Chemical Evolution by A.P. Rudenko*, in: *Философия пограничных проблем науки* [*Philosophy of Boundary Problems of Science*], v. 6, Perm 1974, pp. 172–180; idem, *Целостность химической основы живой материи*, в: *Философия пограничных проблем науки* [*Philosophy of Boundary Problems of Science*], v. 8, Perm 1975, pp. 38–69; Т. С. Васильева [T. S. Vasilyeva], В. В. Орлов [V. V. Orlov], *Химическая форма материи. Химия, жизнь, человек* [*Chemical Form of Matter. Chemistry, Life, Man*], Perm 1983, p. 80; Т. С. Васильева [T. S. Vasilyeva], *Химическая форма материи и закономерный мировой процесс* [*Chemical Form of Matter and Natural World-Process*, Krasnoyarsk 1984, p. 89; Т. С. Васильева, В. В. Орлов [T. S. Vasilyeva], *О теневой химической системе жизни (наследственности)* [*About the Shadow Chemical System of Life (Heredity)*], in: *Философия пограничных проблем науки* [*Philosophy of Boundary Problems of Science*], v. 8, pp. 60–77.

⁵ Л. Я. Няпинен [Leo Näpinen], *Философский анализ двух концепций предбиологической эволюции* [*Philosophical Analysis of Two Concepts of Prebiological Evolution*], Учёные записки Тартуского государственного университета [Scientific Notes of Tartu State University], Tartu 1984, v. 694, 84–96; idem, *О физических основах и философских основах теории М. Эйгена* [*On the Physical Foundations and Philosophical Foundations of M. Eigen's Theory*], in: К. Паавер [K. Paaver] et al. (eds.), *Методологические проблемы эволюционной теории* [*Methodological Problems of Evolutionary Theory*], Tartu 1984, pp. 100–101; idem, *О понятиях организации и самоорганизации в современном естествознании* [*On the Concepts of Organization and Self-Organization in the Contemporary Natural Sciences*], Известия АН Эстонской ССР. Общественные науки [Reports of the Academy of the Estonian SSR. Social Sciences], 1982, 31(1), pp. 95–96; idem, *Об использовании терминологии дарвинизма в современном математическом естествознании* [*On the Use of Darwinian Terminology in Modern Mathematical Science*], in: *Вопросы современного дарвинизма* [*Issues in Modern Darwinism*], К. Паавер [K. Paaver], Т. Сутт [T. Sutt] (eds.), Tartu 1983, pp. 90–101.

standings was provoked by Rudenko himself, “overwhelmed by the desire to prove the absolute superiority of his own “natural history approach to biogenesis.” And I am not talking about this in order to remove the remark (especially since there is a grain of truth in it, the injustice consists only in not understanding the reasons for generalization), but in order to bring our positions closer in understanding the concept under consideration.

You are absolutely correct in asserting that the concept of self-development forms the basis of the theoretical construction of my theory and behind it stands the thesis about the changeability of the laws of evolution, and the thesis about the formation of new properties and functions as well as the natural selection of the most progressive of them while overcoming the limits of development.

However, neither the theory of evolutionary catalysis, nor the general theory of chemical evolution and biogenesis would exist, just as there would be no concept under consideration with all its characteristics,

- if the phenomenon of self-development of elementary open catalytic systems had not been established,
- its boundary conditions had not been specified,
- and the basic law of the progressive evolution of these systems would not have been discovered, which establishes the causes, driving forces of evolution and the mechanism of natural selection.

Only knowledge of the basic law of progressive evolution made it possible to develop a complete theory of self-development, describing it qualitatively and quantitatively and establishing the above principles. This knowledge reflects the main principles of self-development (progressive evolution), explains the main principles of self-development, explains its essence and the cause and effect of progressive development. It is the absence of this knowledge, reliance on it and even signs of possible approaches to it, that distinguishes everything I call “actualistic” theories and hypotheses from the natural-historical theory of biogenesis of open catalytic systems. Just in this respect, the theory of biogenesis of open catalytic systems differs significantly from all other theories, in which the principle of self-development and the ideas of natural selection are not derived from the properties of systems and the conditions of their real evolution and are not proved by strictly scientific methods, as in the first case, but are assumed as desirable for a possible explanation of the origin of life.

The differences between the natural-historical and actualistic approach and the corresponding theories of biogenesis can be seen not only in their content, but also in their heuristic value. On the one hand, the theory of biogenesis of open catalytic systems, based on a natural-historical approach, reveals the reasons, driving forces, the basic law of progressive evolution and the mechanism of natural selection of progressive evolutionary changes

when overcoming the limits of development and is able to fully describe chemical evolution and biogenesis up to the emergence of living organisms, and also to lay the foundations for theoretical description of the existence and further biological evolution of living organisms. Taking these positions, science acquires the ability to solve and really solves a number of complex issues of the problem of biogenesis and gains unlimited prospects for further development in this area.

On the other hand, none of the actualistic theories, including the newest theory of protein-nucleotide hypercycles by M. Eigen, gives an answer to any of the above questions and, what is especially sad, because of the retrospective approach, they are in principle unable to reveal the reasons, driving forces and the basic law of progressive evolution. For transitions through bifurcation points of development can be described unambiguously only in the forward direction of evolution, taking into account its basic law; it is impossible to distinctly describe these transitions in the opposite direction, without knowing the basic law, all the more so it is impossible to reveal the basic law in such a way.

Therefore, the scientific and theoretical deadlock in the problem of the origin of life became obvious, when it is situated on the basis of an actualistic approach, and the authors of such theories themselves (J. Bernal, D. Kenyon, G. Steinman, M. Eigen, etc.) come to the conclusion about the inability of science to describe the entire progressive process of chemical evolution from inanimate matter to the living beings.

There is only one way out of this impasse. The process of evolution must be viewed natural-historically, in the light of the fundamental law that determines its causes, driving forces and the mechanism of natural selection. To do this, you need either to establish the basic law or turn yourself to the theory of evolutionary catalysis, where it has already been established. In this case, it will inevitably have to change not only the approach and methodology of research, but also ideas about the nature of objects and the essence of evolution, since they have quite certain strictly specific features. Here we will have to highlight:

- processuality—as a defining feature of evolution,
- non-equilibrium open catalytic systems—as the only possible object of progressive chemical evolution,
- self-development of the properties and functions of these systems, as well as
- changes in the laws of evolution in its course—as the essence of progressive evolution,
- an increase in the energy potential of metabolic processes ($\Delta T / \Delta t > 0$)—as a condition for the manifestation of progressive evolution, and
- a quantitative measure of progress.

However, it should be noted that understanding the central role of the basic law of evolution in the theory of biogenesis for some reasons presents certain difficulties. This is evidenced by the fact that practically all interpreters of the theory, both in the scientific-theoretical and in the philosophical terms, with whose statements I am familiar, either completely bypass the basic law, or pay negligible attention to it in comparison with more particular questions and consequences of the theory. Meanwhile, a comprehensive consideration of the manifestations of this law and related principles is the basis of the theory itself; invoking these principles explains a number of evolutionary effects and relationships between phenomena that have long remained unclear. For example, taking into account the basic law, the mysterious “entelechy” of Aristotle is explained from the materialistic point of view; the relationship between causal and random events in evolution becomes clear, since all evolutionary changes in systems with the formation of new properties and functions turn out to be strictly determined, and only the implementation of certain specific changes at a given time is random. Taking into account the basic law, a certain connection and subordination of the processes of self-development, self-organization and self-complication of systems, is established.

In the end, interpretative misunderstandings stem from an underestimation of the basic law of evolution and its leading role in evolutionary progress. And here the point is not which approach to the problem of biogenesis is more historical and to what extent this or that theory of biogenesis stands in the position of processualism, but in which theory and on the basis of which approach the basic law of evolution is revealed, which makes it possible to construct a quantitative theory and scientific descriptions of progressive chemical evolution and biogenesis. The law was discovered during the development of the theory of self-development of elementary open catalytic systems, and a complete description of chemical evolution and biogenesis with the help of this law became possible only as an unfolding of the history of nature in the direction in which the evolutionary process was actually going. It was logical to consider that approach “natural-historical.” On the other hand, a retrospective description of life, without exact knowledge of the causes and laws of chemical evolution, but only on assumptions about them based on knowledge of the properties and laws of existence and development of modern living organisms, which is done in all other theories opposed to the theory of biogenesis of open catalytic systems, also it is logical to consider an “actualistic” approach.

Therefore, I believed that such names correspond very closely to the essence of these two approaches, regardless of who and in what sense used these terms earlier. To some extent, they will always be conditional. One could call them in another way, purely conditionally: approach No. 1 and No. 2, and both would retain their essence of the historical method, and it

would still be necessary to characterize the “true historicity” of the first, revealing its specific features and considering the effectiveness of theories created with their help. If we take into account the latter circumstance, then the opposition of the theories developed according to the first and second approaches is fully justified at least for a better understanding of their essence and clarification of the prospects for further research in the field of biogenesis. For in this case we are faced with an extraordinary situation. Adopting two strictly scientific research methods, we get opposite results: either a successful solution to the problem of biogenesis, or a scientific and theoretical dead-end in attempts to solve it.

This is the superiority of the theory of biogenesis of open catalytic systems over all other (“actualistic” ones), and hence the superiority of the natural-historical approach over the actualistic one. And this fact deserves the attention of both scientists-theorists and philosophers.

As you can see, I had quite serious reasons to resolutely oppose the concept of biogenesis of elementary open catalytic systems, based on the first approach and which is so far the only one where this approach has been implemented, to all other concepts and hypotheses of the origin of life based in one way or another on the second approach. My persistence and (possibly) in some respects exaggeration of such an opposition is not at all connected with the ambition of “my own approach,” but with the desire to show the truth I see, on the understanding of which the development of science depends.

ABOUT THE AUTHOR — 1925–2004. Head of the Laboratory of Organic Catalysis at the Faculty of Chemistry of Moscow State University. Author of more than 500 scientific publications, some of which laid the foundation for new directions in chemistry. He has also published a number of works devoted to the philosophy of chemistry and chemical evolution. Interestingly, in addition to lecturing at the chemistry faculty (on “Catalytic chemistry,” “Theoretical foundations of catalysis” et al.), he taught special courses at the Faculty of Philosophy (“Philosophical problems of chemistry”, “The problem of chemical evolution, biogenesis and self-organization of matter,” “The contribution of conceptual systems of chemistry to the understanding of the world”).